



NAVAL RESEARCH LABORATORY

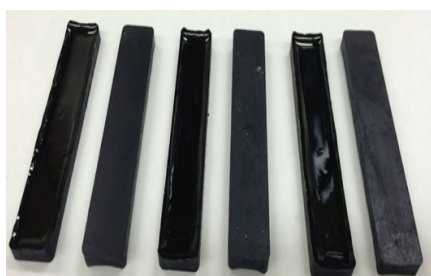
The Corporate Laboratory for the Navy and Marine Corps

PEEK™-like Phthalonitriles: Base Resin Manufacturing

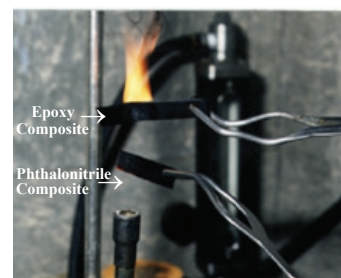
The Naval Research Laboratory (NRL) has developed a new class of PEEK™-like phthalonitrile (PN) resins, when in the melt-state, are easily processed and cured, and produce high-temperature thermosets. The PN base resins are synthesized in a two-step, one-pot reaction in quantitative yields and require no further purification ($n < 1$). A simple workup, along with utilizing cost effective starting materials, make manufacturing these new PN resins competitive to other thermoset base resins. The resin formulations are indefinitely stable under ambient conditions and can be prepared either as a powder or to a specified viscosity (and gel time) for use in existing commercial resin processes. An example of such phthalonitrile-based products are polymer matrix composites (PMC) which exhibit high thermal and oxidative stability approaching 500 °C (930 °F) in air, have low water absorption, retain structural integrity in a fire environment, and show thermal properties that exceeds Navy expectations for composite ship and aircraft applications.



NRL's neat, PEEK™-like phthalonitrile (PN) resin.



PN resin cured (m.p. ~ 70 °C) with 3-5 wt % thermally stable, aromatic amine using a melt-degas-cure procedure.



PN composite fire properties outperform widely used epoxy composites.

Advantages

- New PN resins implore cost-effective manufacturing due to a simple two-step, one-pot reaction in quantitative yields.
- Resin cures via addition reaction, yielding void-free products due to no off-gassing.
- Pre-polymerized formulations are unreactive until ready to use and stable (tens of years) under ambient conditions.
- Only class of polymers to exhibit no T_g before decomposition, dependent on application, when cured under certain conditions.

Application Areas

- Cured lightweight, structural/fire resistant, high-temperature polymers attractive to numerous military and commercial industries:
 - automobile, aerospace, maritime, electronics, sports equipment, oil & gas exploration, wind energy

References

- "Improved Synthesis of Oligomeric Phthalonitriles and Studies Designed for Low Temperature Cure," *J. Poly. Sci., Part A: Poly. Chem.*, **52** (2014) 1662–1668.
- "Improved Synthesis of Oligomeric Sulfone-Based Phthalonitriles," *Macromol. Chem. Phys.*, **216** (2015) 1808–1815.
- PEEK™ is a trademark of Victrex PLC.

Licensing and Collaboration Opportunities

US Patent Nos. 8,735,532; 8,859,712; 8,921,510; and 8,981,036 are available for license to companies with commercial interest. Collaborative research and development is available under a Cooperative Research and Development Agreement (CRADA).